

# PATENT SPECIFICATION

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DRAWINGS ATTACHED.

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## COMPLETE SPECIFICATION.

### Apparatus for Quantitative Indicating of Small and Rapid Volume Changes in a Part of an Extremity.

We, JARNHS ELEKTRISKA AKTIEBOLAG, a Swedish Company, of Industrivagen 23, Stockholm-Solna, Sweden, do hereby declare the invention, for which we pray that a patent may be granted to us, and the method by which it is to be performed, to be particularly described in and by the following statement:—

The present invention relates to a plethysmograph, that is, an apparatus for quantitatively measuring and/or recording small and rapid volume changes taking place in a part of an extremity. In particular, this invention relates to means for obtaining a sealing contact between a rigid shell forming the main body of a plethysmograph, and the extremity, while rigidly maintaining the plethysmograph in position on the extremity.

Rigid contact between known plethysmographs and an extremity has been achieved by means of a diaphragm provided at each end of a rigid plethysmograph tube. Such diaphragms generally consist of rigid laminar structures, each of which is displaceable at right angles to the extremity and is adapted to be secured in position with a part thereof in contact with the extremity. However, it is generally impossible to provide a complete seal between adjacent laminar structures or against the extremity. It has, therefore, become necessary to insert a sealing means, e.g. taking the form of a rubber sleeve, between the laminar structures of the diaphragm and the extremity. The sealing means must be in contact with the inside of the laminar structures as well as with the extremity so that the fluid enclosed by the plethysmograph, i.e. air or liquid, will be enclosed between the sleeve and the rigid shell of the plethysmograph. The mounting of the sleeve on the laminar structures

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and on the extremity is difficult owing to air pockets forming in spaces between the laminar structures, whereby the rigidity of the apparatus, and hence also the accuracy of the results obtained, is reduced. Furthermore, the diaphragms of this type take a considerable time to assemble.

It is an object of the present invention to overcome, or at least mitigate, the aforesaid difficulties.

According to the present invention, there is provided an apparatus for use when quantitatively determining small and/or rapid changes in the volume of a region of an extremity, comprising a rigid tubular shell capable of surrounding, in use, a region of an extremity, means at each end of the shell for sealingly connecting the shell to the extremity, which means comprises a plurality of rigid plates mounted circumferentially of said ends in partially overlapping relationship and being completely enclosed in a flexible covering member connected to said shell, which covering member is adapted to be connected, in use, to air evacuating means, and means for connecting the interior of the shell to volume change indicating means.

An apparatus constructed in the manner according to the invention can be easily and quickly mounted and fixed on the extremity because the rigid plates are hingedly or displaceably adjustable into contact with the extremity. After evacuating the covering enclosing the plates, the plates are fixed or locked in the adjusted position by the external air pressure, which presses the plates against each other, whereby a rigid and sealing contact against the extremity is obtained.

For a better understanding of the invention, and to show how the same can be

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carried into effect, reference will now be made, by way of illustration only, to the accompanying drawing, in which:

Figure 1 is a sectional view of a plethysmograph according to the invention, and applied to an extremity;

Figure 2 is a similar view to that shown in Figure 1 and illustrates a modification of the plethysmograph; and

Figures 3 and 4 are diagrams showing results obtained by means of the plethysmograph.

Referring to the drawing, Figure 1 shows a plethysmograph apparatus 1 mounted about a region 2 of a leg 3. The apparatus comprises a rigid tube 4, at the two ends of which diaphragm means 5 are mounted. These form the end walls of the apparatus and serve as rigid sealing means sealingly engaging the leg 3. The diaphragm means 5 each consist of several rigid plates 6 partly overlapping each other and mounted around the periphery of the tube ends and adjustably contacting the leg 3. The plates 6 can be pivoted with respect to tube 4 by hinges formed of a flexible material such as rubber or a synthetic plastics material providing a flexible connecting web between the plates and the tube. Each of the plates occupies a small portion of the tube periphery. Since the plates are not fixed in one position the diaphragm means can be mounted at any portion of an extremity simply by changing the angle of the cone which they form together.

The plates 6 at each end of tube 4 are completely enclosed in a soft and flexible covering 7 which is connected in an airtight manner to the adjacent tube end. A hose 8 or the like communicates, at one end, with the interior of the covering, and can be connected at its other end to an air suction device (not shown) for evacuating the space formed in the covering. Evacuation of the covering results in the plates 6 being pressed against each other in a position depending on the nature of the extremity with which sealing contact is being made.

It is thus possible to obtain a very good seal between the various plates and between the ends of the plates and the extremity. The rigidity of the whole arrangement is considerable, this being important if accurate measurements are to be obtained when using the plethysmograph. In practice, the volume changes to be indicated are very small, e.g. in the range of 0.1 to 1 ml.

The tube 4 has a connection 9 opening to the atmosphere, and through which the apparatus can be connected to measuring means. Referring to Figure 1, a flow meter 11 which is provided in connection 9 is sensitive to air flow out of or into the plethysmograph tube 4 through connection

9, caused by volume changes of region 2 of the leg 3 enclosed by tube 4. The flow meter 11 can be a pneumotachograph which offers extremely low resistance to air flow, differential pressure across the pneumotachograph being sensed by a pressure transducer 12 communicating with connection 9 through tubes 13 on opposite sides of the pneumotachograph. The pressure measurement represents flow through the pneumotachograph and is converted into an electric signal by the transducer 12. This signal is passed to an amplifier 14 and thence to an integrator 15 wherein the amplified flow signal is integrated with respect to time in order to indicate the volume change. The flow signal provided by amplifier 14 and the volume signal provided by integrator 15 are fed to an ECG-recorder which linearly records volume changes within the region 2. The flow signal can be calibrated using a known constant flow and the volume signal can be calibrated using known volumes of fluid ejected from a syringe.

Figures 3 and 4 show the precise nature of measurements obtained by means of the apparatus according to the invention. The differential pressure emanating from the apparatus is measured and amplified and then recorded by the ECG-recorder. Figure 3 shows the recording of the thigh of a healthy man. The volume within the apparatus was 1 litre and the pulse volume changes amounted to 0.7 ml. The recording was typical of a thigh at rest. Figure 4 is a recording of the blood flow under venous occlusion.

Turning now to Figure 2, there is shown a modification of the plethysmograph according to Figure 1. In this embodiment a hose 10 extends throughout the length of the tube 4. Hose 10 is secured to the ends of covering 7 at those peripheral parts thereof facing the leg, e.g. by welding, in order to provide a good seal with covering 7. Hose 10 is resilient so that it can be distorted as the contours of the covering 7 change. By means of this arrangement it is possible to use a liquid as measuring medium, the liquid being enclosed in the annular chamber formed inside tube 4 by the inner surface of the tube and hose 10.

The apparatus shown in the drawing can be modified within the scope of the invention claimed herein. For example, the plates may be displaceably mounted, e.g. have a slot or groove in the central portion, with which a pin attached to the tube will engage. An arrangement of this kind allows angular displacement of the plates to take place with respect to the extremity.

#### WHAT WE CLAIM IS:—

1. An apparatus for use when quantitatively determining small and/or rapid

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- changes in the volume of a region of an extremity, comprising a rigid tubular shell capable of surrounding, in use, a region of an extremity, means at each end of the shell for sealingly connecting the shell to the extremity, which means comprises a plurality of rigid plates mounted circumferentially of said ends in partially overlapping relationship and being completely enclosed in a flexible covering member connected to said shell, which covering member is adapted to be connected, in use, to air evacuating means, and means for connecting the interior of the shell to volume change indicating means.
2. An apparatus as claimed in Claim 1, in which the interior of the shell contains, in use, air.
3. An apparatus as claimed in Claim 1, in which a flexible elastic tubular member capable of surrounding the region of the extremity, is housed in the shell, which flexible elastic, tubular member is fixedly secured at its ends to the respective coverings at the peripheral parts thereof which contact the extremity, an annular space being formed between the flexible elastic tubular member and the shell which is, in use, filtered with a liquid communicating with the volume change indicating means.
4. An apparatus as claimed in Claim 1, substantially as hereinbefore described with reference to Figure 1 of the accompanying drawing.
5. An apparatus as claimed in Claim 1, substantially as hereinbefore described with reference to Figure 2 of the accompanying drawing.
6. An apparatus as claimed in any preceding claim in association with volume change indicating means.
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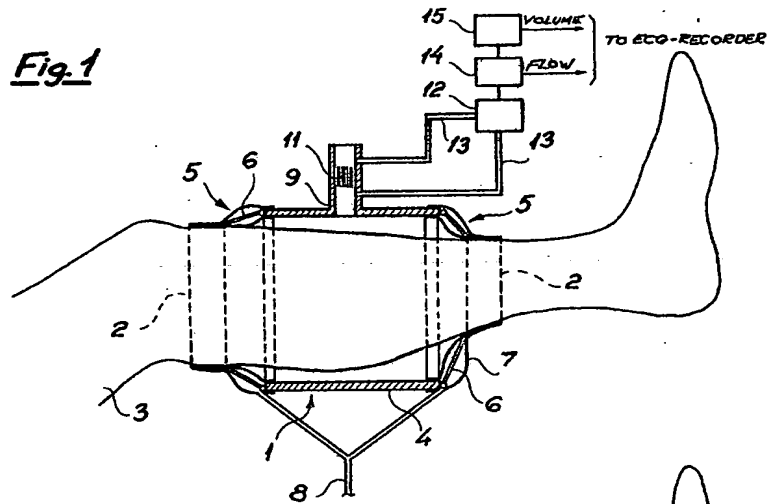
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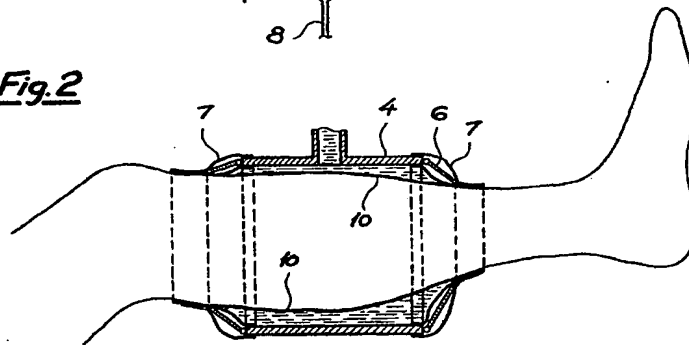
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This drawing is a reproduction of the Original on a reduced scale

**Fig. 1**



**Fig. 2**



**Fig. 3**



**Fig. 4**

